Title: Let's Get Physical

Brief Overview

Students will collect heart rate data at rest, while exercising, and returning to rest, using the TI-CBL. The equations of the resulting piecewise functions are determined. After presenting their results to the class, the students will predict the graphs of heart rates formed as the result of various athletic activities.

Links to NCTM Standards:

- **Mathematics as Problem Solving**
  Students will predict the types of graphs which heart rates from certain exercises will generate, and will adjust their predictions to create the best fitting equations.

- **Mathematics as Communication**
  Students will work in teams to collect, analyze, and present data.

- **Mathematics as Reasoning**
  Students will analyze graphs and data sets and make conjectures about the relationship between heart rate and specific types of exercise.

- **Mathematical Connections**
  Students will relate various functions to heart rate data collected at rest and during various types of exercise.

Grade/Level:

Grades 8-12 (Algebra I, Algebra II, and Pre-Calculus)

Duration/Length:

This activity will take 3 - 4 class periods.

Prerequisite Knowledge:

Students should have working knowledge of the following skills:

- Interfacing the TI-83 Graphing Calculator with the TI-CBL and the Vernier Exercise Heart Rate Monitor
- Collecting data from these instruments
- Describing the graphs of the data generated by the TI-CBL
- Using the TI-83 Graphing Calculator proficiently
- Transferring calculator screens to the computer via the TI GRAPH LINK

Objectives:

Students will:

- work cooperatively in groups.
- collect and organize data from the Polar Hear Rate Chest Belt, the CBL unit, and the TI-83 Graphing Calculator.
- create a mathematical model for a physical situation.
- identify the domains of the piecewise function generated by the data.
- use the Graphing Calculator to come up with regression equations for different parts of the piecewise function.
- recognize graphs of different regressions equations.
- present data and resulting piecewise functions to the class for discussion

Materials/Resources/Printed Materials:

- TI-CBL Unit
- TI-83 Graphing Calculator with Unit-to-Unit Link Cable
- Vernier Exercise Heart Rate Monitor with Polar Chest Belt
- Clock or watch with a second hand
- Programs: CMBHEART from Vernier's CHEMBIO and CHOOSE from Texas Instrument's Real-World Math with the CBL System
- Data Collection Worksheet
- Analysis and Synthesis Worksheet
- Overhead transparency to be used with a printer–one for each group

Development/Procedures:

- Assign each group of three students one of the following exercises: jogging in place, stair stepping, sit ups, chair rise (rising repeatedly from a seated position), half jumping jacks (legs only), toe touches, deep knee bends, and leg lifts
- Instruct students to follow the directions on the Data Collection Worksheet.
- Instruct students to complete the Analysis and Synthesis Worksheet.
- Present the overhead transparency of plots and graphs with explanations of the regression equations chosen to the class.
- Have students write a one-page report supporting their regression equation choices.

Evaluation:

As the students perform the experiment in groups the teacher will circulate in the classroom to monitor students' progress. The Analysis and Synthesis Worksheet, the students' transparencies, and the one page report will be collected and evaluated. Students will be evaluated on their understanding of piecewise functions and regression functions through their verbal presentation.

Scoring might also be based on facility with the use of programs and data manipulation on the TI-83, the CBL, and TI Graph Link, as well as the accuracy of the resulting graphs.

Extension/Follow Up:

- After verbal presentations, students research the importance of exercise to good health, pick a favorite sport and support their choice in a one page report.
- Students collect and graph heart rate data for a person at rest, while exercising, and while returning to a resting state.
- Students predict functions for athletic activities such as basketball, swimming, soccer, hiking, and skiing.

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Let's Get Physical
Data Collection Worksheet

1) Choose one member of the team to be the subject, one to be the calculator operator, and the third person to be the timer.

2) Position the exercise belt on the subject directly below the sternum. The Polar label should be in the middle of the ribs, and the belt should be snug as shown in Figure 1.

3) Use a link cable to connect the CBL and the calculator as shown in Figure 2.

4) Plug the Exercise Heart Rate Monitor into channel 1 on the CBL as shown in Figure 2.

5) Execute the CMBHEART program.
   - Select device "chest belt."
   - Choose "5 second" time intervals.

6) Run the program for a total of four minutes.
   - For one minute the subject should sit quietly.
   - For one minute the subject should exercise as aggressively as possible.
   - For the next two minutes the subject should sit quietly.
   - To end the data collection, press [ENTER].

7) Choose "3" to view a graph of the data.

8) Save a copy of the screen on your disk using TI-Graph Link.

9) To end the program press [ENTER] and then choose "4."

Figure 1

Figure 2

Subject Name: Date:
Calculator Operator's Name: Period:
Timer's Name:

Let's Get Physical
Analysis and Synthesis Worksheet

Part I: Analyzing the Data
Describe the four distinct sections of the graph in terms of the experiment. Locate the beginning and ending points using the Trace function and note whether each section of the function is increasing, decreasing, or neither. (Note: BPM = Beats per Minute)

Section	Experiment Description	Beginning Point (Time, BPM)	Ending Point (Time, BPM)	Increasing, Decreasing or Neither
1				
2				
3				
4				

1. The collected data will be in L3(BPM) and L6 (Time). Transfer Time data to L1 and the Heart Rate data to L2.
2. Isolate section 1 of the graph using the program CHOOSE. This data will be stored in L3 and L4.
3. Looking at this isolated section of the graph, decide what type of function would best fit this data (linear, quadratic, cubic, quartic, logarithmic, exponential or power). Write your conjecture below.
4. Use the calculator to graph various regression equations along with the data, which is stored in StatPlot. Run the regression equations on L3 and L4.
5. To see a graph of the regression equation follow the directions below.
   - Press [Y=] (With section 1, place cursor beside Y1=)
   - Press [VARS]
   - Choose "5" Statistics, press [ENTER]
   - ⇨⇨Choose "1" RegEQ

   Now the regression equation can be graphed with the stored data. Remember the regression equation should best represent data collected before and after the interval as well as during this interval. Use the Zoom Out to look at the entire picture and Zoom In to see the best fit.
6. Write the best fitting regression equation below.

7. Repeat steps 2-5 for the next three sections of the graph, putting the regression equation for section 2 in Y2=, section 3 in Y3= , and section 4 in Y4=.

This may also be done on Home Screen by choosing a regression equation followed by L3, L4, Yn where n = 1, 2, 3, or 4, depending on the section of data being considered. This will automatically place the regression equation in the correct Y =).

Conjecture: Type of Function **Regression Equation**

Section 1: _____

Section 2: _____

Section 3: _____

Section 4: _____

Part II: Constructing the Piecewise Function

Currently the calculator will graph each regression equation over the entire domain, 0 seconds to 240 seconds. In constructing the piecewise function, the goal is have the calculator graph the regression equation over its appropriate domain. Use the beginning and ending points from the table in Part I to write the domains for each regression equation: (Example, if the domain is between 12 and 25, then write $X \geq 12$ and $X \leq 25$)

Domain of regression equation 1: _____

Domain of regression equation 2: _____

Domain of regression equation 3: _____

Domain of regression equation 4: _____

Follow the steps below to assign the appropriate domain to each regression equation on the calculator.

- Press [Y=]
- For each function, insert parentheses around the regression equation
- Following each regression equation, type an open parenthesis, the domain of the appropriate equation above, and a close parenthesis ($x \geq 12$ and $x < 25$). Note: < and ≥ are found under the TEST menu and "and" is found under the TEST ⇨LOGIC menu.
- Press [GRAPH]. This will display the STATPLOT and the regression equations on the calculator screen
- Connect the calculator to the TI GRAPH LINK and select GET SCREEN under the LINK menu to transfer the graph from the calculator to the computer.
- Paste the screen image into any word processor and print a hard copy and also a transparency of the full data stored in Stat Plot 1 for your presentation.

- Prepare a one-page report, which states the various regression equations you tried for each section of the piecewise function. Justify your choice for each section.

Part III: Extending the Ideas

1. How does exercise affect health? What are important characteristics of "effective" exercise?
2. What differences might you expect to see in data collected from someone who exercises regularly or is a couch potato?
3. What differences might you expect to see in the functions produced from the following activities: swimming, football, tennis, hiking, skiing, etc.?
4. What is meant by aerobic exercise? By weight bearing exercise?
5. What is your favorite sport? How does it help you achieve better health?

Let's Get Physical Sample Data

Below are sample graphs from a stair stepping exercise. Figure 1 is a Stat Plot of the data recorded from the TI-CBL heart monitor unit. Figure 2 is the regression curves superimposed over the real-world data.

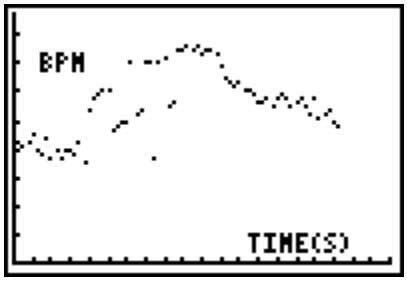

Figure 1

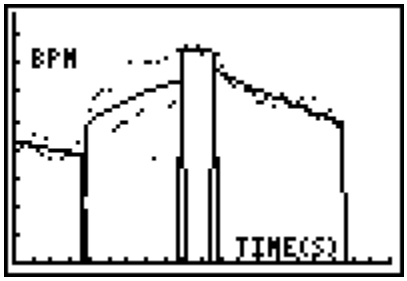

Figure 2